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STRINGOCEPHALUS IN THE DEVONIAN  
OF INDIANA

(WITH 5 PLATES)

By

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ABSTRACT

THE BRACHIOPOD genus *Stringocephalus* is reported in Indiana for the first time. This discovery is of great importance as it places this important Devonian marker of the Givetian Stage in the Devonian sequence of the eastern United States. The Indiana occurrence of *Stringocephalus* is below the Logansport Limestone, but overlies Silurian rocks. Comparison of the fossils accompanying *Stringocephalus* in Indiana with those of other formations in the United States and Canada indicates a close correlation with the Rogers City Limestone of Michigan and the Winnipegosis Formation of Manitoba. Correlation of *Stringocephalus* fauna in Indiana with that of Rogers City in Michigan indicates *Stringocephalus* in Indiana lies in the midst of the Cazenovia Stage of the Devonian.

One new species of *Subrensselandia* is described and the specimens of *Stringocephalus* are described and discussed.

INTRODUCTION

Since the discovery of Devonian rocks in eastern United States the exact position of *Stringocephalus* has been a matter of speculation because no specimens have hitherto been found. *Stringocephalus* is a large and distinctive brachiopod that is generally regarded as the leading fossil of the Givetian Stage of the Middle Devonian.<sup>1</sup> This genus is worldwide in distribution and is well known or common in many localities in Europe and Asia. It is also known from Australia

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<sup>1</sup> Also reported but rare in the Eifelian (Struve, 1961).

and north Africa and occurs more rarely in western United States and Alaska (Kirk, 1927). In western and northwestern Canada (Warren and Stelck, 1962; Crickmay, 1960) it is common in places and occurs through a fairly thick sequence of rocks. It has, however, until now, not been seen in the United States east of the Great Basin. Its report from Minnesota by Schuchert (1897, p. 417; Stauffer, 1922, p. 408) has never been authenticated. Consequently, the discovery of this important brachiopod by the second author helps to bring some of the stratigraphic problems of the Devonian of eastern United States into better focus. Some questions, however, are still left unanswered. It further supports the contention (Cooper, in Cooper et al., 1942, p. 1784) that the earliest occurrence of *Stringocephalus* in eastern United States is in the midst of the Cazenovia Stage.

In the winter of 1963 the second author reported to the U.S. National Museum discovery in the Wabash Valley of Indiana of a large brachiopod from limestone hitherto classified as Onondaga (Jeffersonville) by E. M. Kindle (1900) or Hamilton by Cooper and Warthin (1941). Although the first specimens submitted are mostly fragmentary and poorly preserved, they are unmistakably *Stringocephalus*. They indicate a shell about 3 inches wide,  $2\frac{1}{2}$  to 3 inches long, and 1 to 2 inches thick. The pedicle valve has an enormous, long, duplex septum which might be mistaken for the Silurian genus *Pentamerus*, often common in rocks subjacent to those containing *Stringocephalus* in Indiana. The brachial valve is provided with a long forked cardinal process.

A further discovery by the second author of the large brachiopod *Subrensselandia* in the same limestone that contains *Stringocephalus* adds additional information of great importance in the stratigraphy of the Devonian.

In June following the initial discovery, a party from the U.S. National Museum consisting of Drs. J. T. Dutro and W. A. Oliver, Jr., of the U.S. Geological Survey and G. A. Cooper was guided by Phelan to important localities. Although no first-rate specimens of *Stringocephalus* were taken, its position in the sequence is now established. Additional fossils were discovered that permit correlation of the *Stringocephalus*-bearing limestone with formations in the United States and Canada.

**Localities.**—*Stringocephalus* was taken from the upper 18 inches of a gray limestone abounding in stromatopores on the west side of the France Stone Company Quarry, on the north side of U.S. Highway 24, 2 miles east of the city limits of Logansport, Logansport ( $7\frac{1}{2}$ )



Quadrangle, Ind. (USNM Cooper locality 381a). The west side of the quarry has long been abandoned and the exposed upper surface of the gray limestone has been weathering for many years, a fact that helped to make the *Stringocephalus* visible.

The following section of the gray *Stringocephalus*-bearing limestone was measured on the west wall of the quarry :

	<i>Feet</i>
<b>Post-gray limestone</b>	
C. Pinkish or cream colored coarsely granular limestone in patches . . . . .	0.5
<b>Gray limestone</b>	
B. Gray, fine-grained limestone containing abundance of stromatopores (pl. 1, fig. 2) of all sizes up to 4 feet, a few corals, both solitary and colonial, and <i>Stringocephalus</i> in the upper 18 inches only. Corals and stromatopores usually upset or upside down; bedding crude or nonexistent. Uppermost surface with scattered fish fragments and sand patches . . . . .	10
A. Gray sandy limestone, the sand grains frosted and well rounded, often in patches or in small channels, resting on an irregular surface with at least 6 inches of relief . . . . .	5

**Silurian (Kokomo) dolomite**

At this place the corals make up less than 10 percent of the coralline materials. The limestone might be described as a coralline conglomerate because the corals and stromatopores are essentially boulders in their helter-skelter orientation. On the west side of the quarry *Stringocephalus* occurs in two well-defined patches. The one on the southwest side is characterized by abundance of the twiglike stromatopore *Amphipora* (pl. 1, fig. 1), but this fossil does not occur at the patch on the northwest side.

The gray limestone is well displayed in the general vicinity of the quarry. Good exposures may be studied southwest of the quarry where the Pottawatomie Point Road, 1.35 miles east of Logansport city limits, cuts through 11 feet of the gray limestone about ¼ mile south of the intersection with U.S. Highway 24. On both sides of this cut and in the field and woods on the west side of the road *Subrensselandia* is abundant 6½ feet below the top (USNM Cooper

locality 391b). The gastropods *Mastigospira* and *Buechelia tyrrellii* (Whiteaves) and the large, distinctive pelecypod *Liromytilus attenuatus* (Whiteaves) occur in the topmost layer. Good exposures also appear on the Fry Farm on the east side of the Cass Station Road,  $\frac{1}{4}$  mile south of its junction with U.S. Highway 24, 3 miles east of Logansport City limits (USNM Cooper locality 391c). Here the large gastropod *Omphalocirrus manitobensis* (Whiteaves) occurs and large *Paracyclas* sp. is common.

A single valve of *Stringocephalus* (146119) was found on the upper surface of the gray limestone 0.2 mile west of Pottawatomie Point Road on a small knob (USNM Cooper locality 391e), demonstrating its presence above *Subrensselandia* but at the same level as *Liromytilus*.

**Stratigraphic relationships of the gray *Stringocephalus*-bearing limestone.**—The gray limestone rests unconformably on Silurian dolomite and is overlain unconformably by the Middle Devonian Logansport Limestone described by Cooper and Warthin (1941, p. 259). The Logansport Limestone, the fauna of which is well dated as lower Ludlowville in age by reference to the New York Devonian, thus gives a definite ceiling to this occurrence of *Stringocephalus* and *Subrensselandia*. The positioning of these two fossils in relation to beds lower in the Devonian can only be obtained by elaborate correlations as detailed below.

Cooper and Warthin (1941) selected as type section of the Logansport Limestone the good display at Pipe Creek Falls about 7 miles southeast of Logansport. This section includes 1 to 6 feet of stromatopore and coral-bearing gray limestone at the base followed by richly fossiliferous, cream-colored granular limestone. The basal bed has all the lithological characters of the *Stringocephalus*-*Subrensselandia*-bearing beds, but these important fossils were not seen.

In the France Stone Quarry the *Stringocephalus*-bearing gray limestone is overlain by granular limestone containing the characteristic fossils of the Logansport Limestone. Strong unconformity is shown at the contact of the Logansport and the *Stringocephalus*-bearing gray limestone by truncation of corals and stromatopores, sand patches, and scattered fish debris in the top of the gray bed. Cooper and Warthin included the gray limestone in their Logansport Formation, but it is evident that it must be divorced from this association. The fauna of the Logansport, which does not include that of the gray limestone from which Cooper and Warthin had only unidentified corals and stromatopores, has been clearly established to be the

same as that of the Centerfield Member of the Ludlowville Formation of New York, the Hungry Hollow Formation of southwestern Ontario, Canada, the Four Mile Dam Limestone of eastern Michigan, and the Beechwood Limestone of the famous Falls of Ohio section in southern Indiana and northern Kentucky (Cooper and Warthin, 1942). Kindle (1900) originally dated all of the Logansport as Onondaga in age, equal to the Jeffersonville Limestone of the Falls of Ohio area. On the contrary, Cooper and Warthin (1941, p. 259) and Campbell (1942, p. 1068) showed that Kindle's leading Jeffersonville guide fossil, "*Spirifer acuminatus*," is in reality one of the *Spinocyrtia granulosa* tribe characteristic of the Hamilton group. Associated species also proved to be Hamilton rather than Onondaga species. They (Campbell, 1942, p. 886) also showed that the fauna accompanying Kindle's "*S.*" *acuminatus* is the widespread Centerfield fauna. Thus the *Stringocephalus-Subrensselandia*-bearing gray limestone of Indiana is pre-Ludlowville and post-Upper Silurian, its fossils completely eliminating any possibility of Onondaga age of these beds.

**Miami Bend, new formation.**—From the above remarks it is evident that the *Stringocephalus-Subrensselandia*-bearing gray limestone must be separated from the Logansport and given its own name. We propose *Miami Bend* for it, from the community near the bend of the Wabash River slightly less than a mile southwest of the France Stone Quarry, Logansport-Anoka ( $7\frac{1}{2}'$ ) Quadrangles. North of the bend 0.3 mile is located the *Subrensselandia* locality (USNM Cooper 391b) on Pottawatomie Point Road. The best exhibition of this limestone and the one best showing its relationships, however, is in the France Stone Company Quarry. We, therefore, select the west side of the quarry as the type section, but derive the name from Miami Bend. On the west side of the quarry the formation is 15 feet thick and is overlain by patches of the Logansport. On the southeast side of the quarry it is 11 feet thick and is overlain by 14 feet of Logansport Limestone. The same relationship appears on the west side of the Pottawatomie Point Road where the northwesternmost exposure, on the west side of a small isolated knob, is composed of Logansport Limestone. The two lithologies are readily separable because the Miami Bend is light gray and fine-grained limestone full of stromatopores, whereas the Logansport is coarsely granular, crinoidal limestone often cream yellow to pinkish, with only a few but different stromatopores and numerous corals.



## GUIDE FOSSILS

The two principal fossils forming the subject of this discussion need further explanation to help make the correlation of the Miami Bend Formation clearer. *Stringocephalus* (Cloud, 1942, p. 104) is well known anatomically and needs no discussion of its morphology. Its occurrence in North America is poorly known and its stratigraphic range is not clearly understood. Furthermore, fossils accompanying *Stringocephalus* are poorly known individually and as a fauna. Consequently, remarks on these subjects may require revision as knowledge of them advances.

*Stringocephalus*, in spite of the fact that it is known to occur rarely in the Eifelian (Struve, 1961, p. 328), is still regarded as the leading fossil of the Givetian, which is often spoken of as the *Stringocephalus* zone. Identification of Eifelian *Stringocephalus* will largely depend on its accompanying fauna, whereas abundance of the genus is likely to indicate Givetian age. In North America, as elsewhere, *Stringocephalus* is a gregarious genus, occurring in banks or patch reefs and often in great abundance. A number of species of *Stringocephalus* have been created in Canada where it occurs throughout a fairly long sequence (Warren and Stelck, 1962; Crickmay, 1960 and 1962). Colonial genera, such as *Stringocephalus* and the pentamerids *Rhipidium* and *Pentamerus* that live in the same manner, are extremely variable locally, each patch often having its own species or subspecies. This leads paleontologists to create many species or to extreme conservatism depending on training or inclination. The North American occurrences are still too poorly known to have tested the usefulness of the described species. Obviously, this is a considerable handicap in correlation, especially between areas that are separated by long distances, as between Indiana and Manitoba and the Northwest Territories, Canada.

*Subrensselandia* (Cloud, 1942, p. 92) (type species *Newberria claypolii* Hall from the Hamilton Group in Pennsylvania) is an aberration of *Rensselandia* (formerly *Newberria*) differing from that genus only in the presence of small struts under the broad hinge plates of the brachial valve (pl. 2, fig. 4). Externally the two genera are identical. *Rensselandia* (Cloud, 1942, p. 94) occurs in Europe in close association with *Stringocephalus* and is probably as good a guide to the Givetian as that genus. It is not reported from the Eifelian. In the United States it is common in the Cedar Valley and Callaway Limestones of Iowa and Missouri. It is also known from MacKenzie Valley in the Northwest Territories and from the Nevada



	IOWA	CENTRAL MISSOURI	E. MISSOURI S.W. ILLINOIS	SOUTHERN INDIANA	INDIANA WABASH VALLEY	CENTRAL OHIO	MANITOBA	SOUTHEASTERN WISCONSIN	EASTERN MICHIGAN	SOUTHWESTERN ONTARIO	NORTHEASTERN OHIO	NEW YORK (GENERALIZED)	STAGE	
	SWEETLAND CREEK	GRASSY CREEK	ALTO	BLAKISTON	DELPHI	OLENTANGY	MANITOBA GROUP (PART)	KENWOOD	SQUAW BAY	KETTLE POINT	HURON	GENESEE	FRASNIAN (FINGER LAKES)	
GIVETIAN	CEDAR VALLEY WAPSINICON	CALLAWAY MINEOLA ASHLAND COOPER		BLOCHER	LITTLE ROCK CREEK ?	OLENTANGY (PART)	MANITOBA GROUP (PART)	NORTH POINT MILWAUKEE THIENSVILLE ?	THUNDER BAY POTTER FARM			GENESEE TULLY	TAGHANIC	
												MOSCOW	TIOUGHNIOGA	
									NORWAY POINT	IPPERWASH PETROLIA WIDDER		LUDLOWVILLE		
			LINGLE	BEECHWOOD	LOGANSPORT	PROUT			FOUR MILE DAM ALPENA	HUNGRY HOLLOW	TEN MILE CREEK	CENTERFIELD		
			ST. LAURENT				PLUM BROOK		NEWTON CREEK GENSHAW FERRON POINT	ARKONA		SILICA (PART)	SKANEATELES	CAZENOVIA
				SWANVILLE SILVER CREEK					ROCKPORT QUARRY BELL					
			BEAUVAIS		MIAMI BEND			WINNEPEGOSIS ELM POINT	LAKE CHURCH (PART)	ROGERS CITY				
	EIFELIAN			GRAND TOWER = DELAWARE	DEPUTY  SPEEDS		DELAWARE		LAKE CHURCH (PART)	DUNDEE	DELAWARE	SILICA (PART) BLUE BED	DUNDEE	MARCELLUS
		?	SILURIAN	ORDOVICIAN	GRAND TOWER	JEFFERSONVILLE	SILURIAN	COLUMBUS	SILURIAN	SILURIAN	BOIS BLANC	ONONDAGA	DETROIT RIVER	ONONDAGA

Fig. 2.—Chart showing the position of the Miami Bend Formation of the eastern United States and Canada and its correlation with other formations.

Limestone in the Great Basin. It has not been found with *Subrensselandia* except in Germany, but too little is known of either genus to say whether or not a time value may be attached to the presence or absence of supports under the hinge plates. Besides the type species another is known from the Middle Devonian of Germany. In the United States *Subrensselandia* occurs in central Pennsylvania, Missouri, and Michigan. The latter occurrence is known from a few specimens only and has not been described.

#### CORRELATION OF THE MIAMI BEND FORMATION

The obvious relationship of the Miami Bend Formation is with other occurrences of *Stringocephalus* and *Subrensselandia*. One salient point of comparison occurs in Canada and another in the northern end of the southern peninsula of Michigan. The Indiana formation shares the same fauna with these other two occurrences. Correlation with these two reference sections permits correct positioning of the Miami Bend in the Devonian. Other similar but less clear points of reference occur in Pennsylvania and Missouri.

**Correlation with Manitoba sections, Lake Manitoba-Lake Winnipegosis area.**—The Devonian in Manitoba is divided into two groups: The Elk Point Group and the Manitoba Group at the top. The former is divided in ascending order into the following formations: Ashern, Elm Point, Winnipegosis, and Prairie. The first and last, which is an evaporite, do not have fossils. The middle two are highly fossiliferous, the Elm Point characterized by *Atrypa arctica* Warren and the Winnipegosis abounding in *Stringocephalus*. This formation is of most concern in comparison with the Indiana occurrence.

The Winnipegosis Formation, besides *Stringocephalus*, contains the gastropods *Mastigospira*, *Buechelia tyrellii* (Whiteaves), and *Omphalocirrus manitobensis* (Whiteaves), and the elongated pelecypod *Liromytilus attenuatus* (Whiteaves), all of which occur in the Miami Bend Formation. *Subrensselandia* has not yet been reported from the Winnipegosis Formation, but the fossils recorded establish a satisfactory correlation with the Indiana fauna.

**Correlation of the Miami Bend Formation in Michigan.**—In Michigan, Ehlers and Radabaugh (1938) established a striking correlation with the Winnipegosis Limestone in their description and establishment of the Rogers City Formation. This formation, about 70 feet thick, contains a buff dolomite of 8 to 9 feet at the base that contains the brachiopod *Carinatina*, known also from the Lake Church Formation of Wisconsin and the Hume Formation of western

Canada. This bed is followed by about 8 feet of chocolate brown limestone containing exquisite, frilled *Atrypa* and *Subrensselandia*. The upper part of the next succeeding bed, 55 feet thick, contains the diagnostic Winnipegosis mollusks: *Mastigospira*, *Buechelia tyrrellii*, *Omphalocirrus manitobensis*, and *Liromytilus attenuatus* (LaRoque 1950). Although *Stringocephalus* has not yet been found in Michigan, the Rogers City Limestone, nevertheless, can be positioned in relation to the above sequence in Canada and in the Hamilton (Traverse) Group of Michigan.

The Rogers City Formation cannot be correlated with any formation east and south of Michigan except the Miami Bend, but it can be fixed in the standard New York section by establishing correlates in the Traverse Group above and the Hamilton Limestone below it. The Rogers City is underlain by the Dundee Limestone (*Brevi-spirifer lucasensis* zone) which for years has been correlated with the Delaware Limestone of Ontario and Ohio and via that formation to the Marcellus of New York. Thus the base on which the Rogers City rests is Marcellus. Further relations to New York are established through the Traverse Group which lies on the Rogers City.

The Traverse immediately overlying the Rogers City is definitely Hamilton in age except for the upper part which has been referred to the Taghanic Stage (Cooper et al., 1942, chart). In the midst of the Traverse is a great coral zone which is culminated by the Four Mile Dam Limestone. This contains *Fimbrispirifer venustus* (Hall) and many other fossils of the New York basal Ludlowville Centerfield Member (Cooper and Warthin, 1942, p. 886) and the Logansport of Indiana. Between this Centerfield equivalent and the Rogers City Formation several formations intervene, which by position and fauna are equated to the Skaneteles Formation of New York. The Rogers City and its partial equivalent, the Miami Bend Formation, are consequently placed between the Marcellus and Skaneteles Formations of the New York succession. It must be emphasized that the *Stringocephalus-Subrensselandia* sequence in question thus falls very low in the Hamilton Group (about middle Cazenovia Stage) and that the Skaneteles, Ludlowville, Moscow, and Tully Formations overlie it.

**Other correlations of the Miami Bend in the United States.**—The type species of *Subrensselandia* is common in parts of south central Pennsylvania (Perry County) where it occurs in the Montebello Sandstone (Ellison, 1963). According to Ellison, *Subrensellandia claypolii* (Hall) forms a zone in the Montebello Sandstone above beds



with *Paraspirifer*, but below a coral biostrome that is equated with the Centerfield Member of the Ludlowville Formation. The presence of *Paraspirifer* suggests a level high in the Marcellus (Cooper, in Cooper et al., 1942, p. 1775). Thus *Subrensselandia* in Pennsylvania occurs in the same relative position that it occupies in Michigan. It is difficult in these fairly uniform clastics, such as the Montebello, to sort out and definitely identify the parts that are Marcellus and Skaneateles, except for the vague limits indicated by the occurrence of the mentioned fossils or faunas.

An occurrence of *Subrensselandia* in Missouri will complete the known areas occupied by the genus. In the much faulted Ste. Genevieve County area, *Subrensselandia claypolii* is reported in the Beauvais Sandstone (Croneis and Hoffman 1931) of uncertain position. This brachiopod was also found by Warthin and Cooper in the interesting section southeast of Union School in Perry County, Altenburg (15') Quadrangle in eastern Missouri, where its position could be established. Here it occurs between a Delaware-Dundee equivalent containing *Brevispirifer lucasensis* (Stauffer) and the St. Laurent Limestone which has Skaneateles affinities. Its position is thus the same as that of the Rogers City Limestone of Michigan.

## PALEONTOLOGY

### **SUBRENSSELANDIA SUBPYRIFORMIS** Cooper and Phelan, new species

Large for the genus; shell thin except at the umbones; length about twice the width; valves of nearly equal depth, the ventral valve having a slightly greater depth than the other; outline inverted pyriform; profile the same. Sides posteriorly gently rounded but anteriorly nearly straight and tapering to about half the maximum width at the anterior; widest posterior to midvalve. Anterior commissure rec-timarginate. Cross section forming a narrow ellipse. Pedicle valve beak small, incurved, and almost recumbent on the umbo of the brachial valve; foramen small. Surface smooth.

Pedicle valve interior with long, flaring dental plates; muscle scars moderately deeply impressed, the diductor scars subflabellate, and the adductors in a narrow groove between them. Vascula media long and broad. Genital markings subreniform, located in posterolateral shoulder.

Brachial valve interior with hinge plates supported by short struts; adductor field small, scars longitudinally striated. Vascula media short, indistinct.



*Measurements in mm.—*

	Length	Brachial valve length	Maximum width	Anterior width	Thickness
Holotype	54.7	52.0	24.0	17.0	31.0
146121 b	56.0	55.4	25.8	20.0?	31.3
146121 c	55.8	?	30.3	18.1	17.0?
146121 d	?	58.8	31.2	15.5	18.6
146121 e	53.4+	51.0+	32.9	21.0?	29.9
146121 f	50.1	48.4	25.0	15.5?	28.7

*Stratigraphic occurrence.*—Miami Bend Formation.

*Locality.*—Cooper 391b.

*Diagnosis.*—Large subpyriform *Subrensselandia* having a narrowly elliptical cross section at right angles to its length.

*Types.*—Holotype 146121a, figured paratypes 146121c-h, k, l, unfigured paratypes 146121b, i, j.

*Comparison.*—The only species to which *S. subpyriformis* can be compared is *S. claypolii* (Hall), the type species of the genus. Hall's species is also subpyriform and has an outline very similar to that of the Indiana species. The latter differs from the Pennsylvania species in having much deeper valves, thus producing an elliptical cross section in the direction of the thickness of the valves, i.e., dorso-ventrally. The cross section of *S. claypolii* is the opposite to that of *S. subpyriformis* because its valves are much less deep and are more transverse.

*Discussion.*—The narrowly elongate form and shouldered appearance of this species are distinctive. In some specimens when adulthood is reached and the shell is no longer growing anteriorly and laterally, shell layers are added at almost right angles to these directions and the brachial valve then tends to grow ventrally and add depth to the shell. Some pedicle valves show a tendency to dorsad growth in the late stages.

Preservation of the Miami Bend *Subrensselandia* is not good for exterior details. The matrix adheres so closely to the shell surface that it is almost impossible to obtain the beak and the exterior, except for the one specimen figured. Internal moulds, however, are excellent and afford good details of the muscle scars, pallial and genital marks. The vast majority of specimens are detached valves, often shingled together and difficult to separate. Complete specimens are rare and are usually at an angle to the crude bedding of the separated shells. In some instances they lie across the bedding or are transversely fractured by jointing or weakness in the rock.

Furthermore, some of the complete specimens are crushed in various directions with the result that only a few are available for description. Actually, we do not have a perfectly formed specimen with both valves attached.

This species of *Subrensselandia* is not likely to be confused with any known species of *Rensselandia*. The enormous *R. missouriensis* (Swallow) is much larger and much thicker and wider; *R. johannis* (Hall) is smaller and not pyriform in either profile or outline; *R. laevis* (Meek) is still larger than the Indiana species, is more robust, and has more rounded outlines and profile; it is distinctly not pyriform; *R. cordiforme* Stainbrook is a small rounded form.

As reported above, specimens of *Subrensselandia* have been taken in eastern Missouri along the Mississippi and from the Rogers City Formation in Michigan. Specimens from these places in the national collections are too fragmentary for description.

It is interesting to note that occurrences of this genus, like those of *Rensselandia* and *Stringocephalus*, often occur as bioherms or biostromes consisting mostly of individuals or detached valves of one species, often exhibiting great variation. Similar "banks" of large pentameroids, such as *Pentamerus* and *Rhipidium*, are known. A bank of the latter in southern Perry County, Tenn., consists of 20 feet of limestone mostly composed of *Rhipidium*. Occurrences of great numbers of *S. claypolii* occur in the Montebello Sandstone of Pennsylvania.

#### STRINGOCEPHALUS, species A

Large, roundly but transversely elliptical in outline with the maximum width at about midvalve; hinge narrower than the midwidth and producing distinct shoulders at the extremities; posterolateral extremities narrowly rounded; sides strongly rounded; anterior margin broadly rounded but the anterolateral extremities broad. Valves unequally convex, the pedicle valve having the greater convexity. Beak small, short, sharply pointed, and forming an angle of 94° to 110°. Beak ridges sharp; interarea narrow; deltidial plates concave and foramen small and oval. Surface smooth.

Pedicle valve moderately convex in lateral profile and broadly convex in anterior profile with the median region somewhat narrowly convex. Median region in young specimens somewhat narrowly swollen, the swelling dying out anteriorly; posterolateral flanks steep.

Brachial valve gently convex in anterior and lateral profiles; somewhat more convex in the posterior region; posterior margin nearly

straight. Median region somewhat flattened but lateral regions sloping gently to the margins.

Pedicle valve interior without dental plates but with a long prominent septum duplex that extends from the apex for three-fourths the length toward the anterior margin. Septum highest about 0.6 the length from the beak where it has a sharp crest, then falls off rapidly with a steep slope to its end.

Brachial valve interior with a short, low median septum, highest posteriorly and extending slightly anterior to midvalve; cardinal process huge and forked in the large specimens with a broad, stout shaft and short prongs that diverge at about an angle of 24°. Cardinal process in a specimen 55 millimeters long, measuring 18 millimeters in length. Hinge plates stout. Loop not seen.

*Measurements in mm.*—

	Length	Brachial valve length	Maximum width	Hinge width	Thickness
146122 a	56.4	48.8	75.5*	46.0*	27.4
146122 b	68.3	58.5?	80.8*	52.5?	28.0+
146122 c	69.3	?	76.5	?	?
146122 d	63.0?	53.0?	86.0?	50.0?	32.0?
146122 e	?	?	98.9	95.0?	50.0+

*Stratigraphic occurrence.*—Top of Miami Bend Formation.

*Localities.*—391a, 391e.

*Diagnosis.*—Medium-sized to large *Stringocephalus* having a short narrow beak, gentle convexity, a wide hinge, and moderate thickness.

*Types.*—Figured and measured specimens: 146122 a, b, e, f; measured specimens: 146122 c, d; unfigured specimens: 146122.

*Comparison.*—Of the many species of *Stringocephalus* recently described only two are like that from the Miami Bend Formation: *S. chasmognathus* and *S. aleskanus* Crickmay, both from the upper part of the Ramparts Formation=Beavertail Formation. Both species are characterized by considerable width and a very short beak. The measurements of the holotype of *S. chasmognathus* are similar to those of the Miami Bend specimens, especially 146122b, except for the thickness which appears to be greater in the Canadian species. Crickmay's sections (1960, p. 886) of this species indicate less massive internal structures than those inside the Indiana specimens. The measurements of the holotype of *S. aleskanus* are very similar

\* Based on half measure.



to those of our specimen 146122b except for the thickness. Our specimen has definitely been crushed and the true thickness is not known. The interior structures of *S. alaskanus* cannot be compared with ours because Crickmay's sections are not cut through the cardinal process to show the forks. The structures that are shown seem to be less massive than those in our specimens. The Indiana specimens seem to us to compare more favorably with *S. chasmognathus* of the two Canadian species. The proportions and short beak are similar but the beak of the Indiana form is slightly longer, more erect and sharper. Furthermore, the Indiana species seems to have been slightly more slender.

*Discussion.*—The preservation of the *Stringocephalus* from the Miami Bend Formation is very poor. The shells are partly cemented to the matrix in many cases so that one must resort to grinding with dental abrasive wheels to free them. In others where the shell and matrix make contact the shell is wholly or partly disintegrated and an irregular seam of clay appears. In such cases that part of the shell in contact with the clay is completely destroyed.

Only one complete specimen had both valves in contact. Several of our specimens are single valves. Consequently, we were unable to make any sections through the shell.

#### STRINGOCEPHALUS, species B

A single poorly preserved specimen indicates another species of *Stringocephalus*. This specimen is 83 millimeters long by 65 millimeters wide at its widest part somewhat anterior to midvalve. The beak is fairly long and strongly incurved like that of *S. burtini*. The deltidial region is estimated at about 23 millimeters in length and is strongly concave. The exterior is not preserved but a good view of the septum may be had. This is extremely long, measuring 120 millimeters along the curve of the valve and terminating about 10 millimeters posterior to the anterior margin. The septum is duplex and thickest about one-third its length from the beak.

This specimen has some features, especially the strongly incurved beak, reminiscent of *S. sapiens* Crickmay and *S. vernaculus* Crickmay. The former species seems not to have been as large as the Indiana one and its median septum is indicated as shorter (60 to 70 percent of the length). *Stringocephalus vernaculus* is also not so large as the Indiana specimen but it has a strongly incurved beak like it. The median septum, however, is only 70 percent of the length, whereas in the Miami Bend specimen it is fully 90 percent of the length.



*Stringocephalus axius* is another large species described but not well illustrated by Crickmay. It is of the same order of size as the Indiana specimen but its beak was shorter and strongly incurved. *Stringocephalus axius* is also indicated as a rather narrow species.

The occurrence of worn and weathered *Stringocephalus* in which the duplex septum is exposed could readily be mistaken for *Pentamerus* and the beds enclosing them inadvertently be assigned to the Silurian.

*Stratigraphic occurrence.*—Top of Miami Bend Formation.

*Locality.*—391a.

*Types.*—Figured specimen 146120.

#### LOCALITIES OF MIAMI BEND FORMATION

##### LOGANSPORT (7½') QUADRANGLE, INDIANA

391a.—Upper 18 inches of Miami Bend on the west side of France Stone Company Quarry, SW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sec. 27, T 27 N, R 2 E, on north side of U.S. 24, 2 miles east of Logansport city limits.

391b.—Beds with *Subrensselandia*, 6½ feet below the top of the Miami Bend Formation, in the road cut and in the woods, 150 feet west of the Pottawatomie Point Road,  $\frac{1}{4}$  mile south of its junction with U.S. Highway 24, NE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , SE  $\frac{1}{4}$  sec. 28, T 27 N, R 2 E, 1.35 miles east of city limits of Logansport.

391c.—Beds with *Liromytilus*, 6½ feet above *Subrensselandia* at the top of the formation, 150 feet west of Pottawatomie Point Road road cut,  $\frac{1}{4}$  mile south of junction of Pottawatomie Point Road and U.S. Highway 24, NE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , sec. 28, T 27 N, R 2 E, 1.35 miles east of city limits of Logansport.

391d.—Miami Bend Formation on Fry Farm, east side of Cass Station Road, 0.4 mile south of its junction with U.S. Highway 24, NW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , SW  $\frac{1}{4}$  sec. 25, T 27 N, R 2 E, 3.4 miles east of the city limits of Logansport.

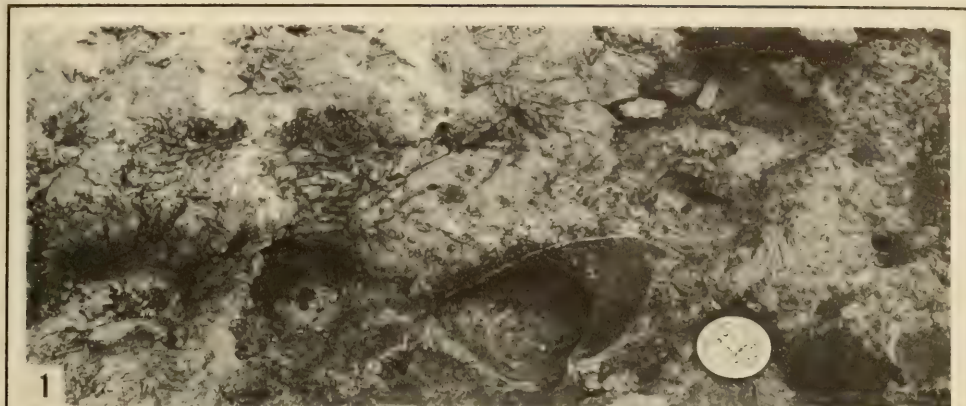
391e.—Top of the Miami Bend Formation on the Oscar Miller property, 0.2 mile south and 0.2 east of the junction of U.S. Highway 24 and Pottawatomie Point Road, NW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , SE  $\frac{1}{4}$  sec. 28, T 27 N, R 2 E, 1.35 miles east of Logansport city limits.

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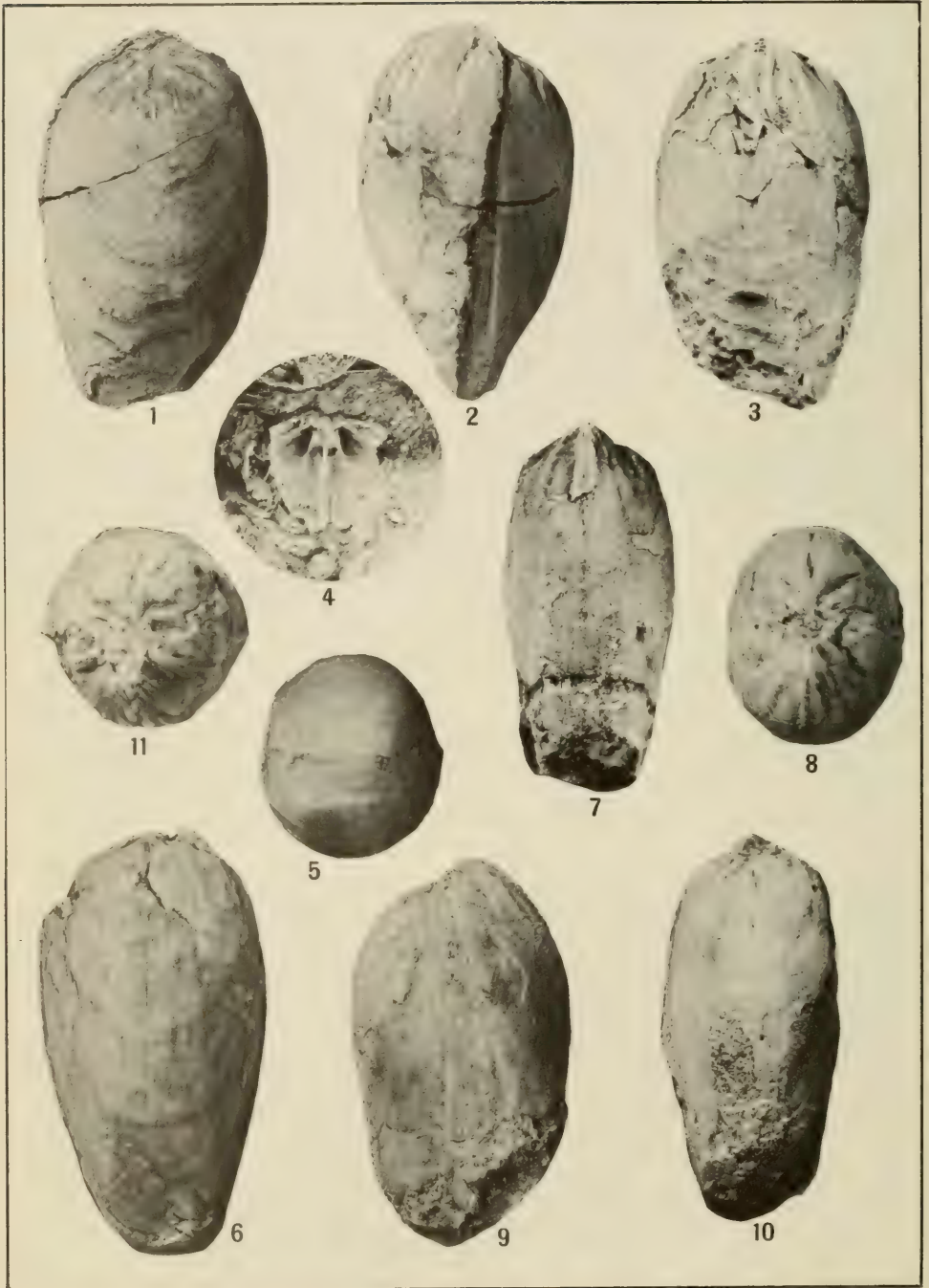




MIAMI BEND FORMATION, FRANCE STONE COMPANY QUARRY

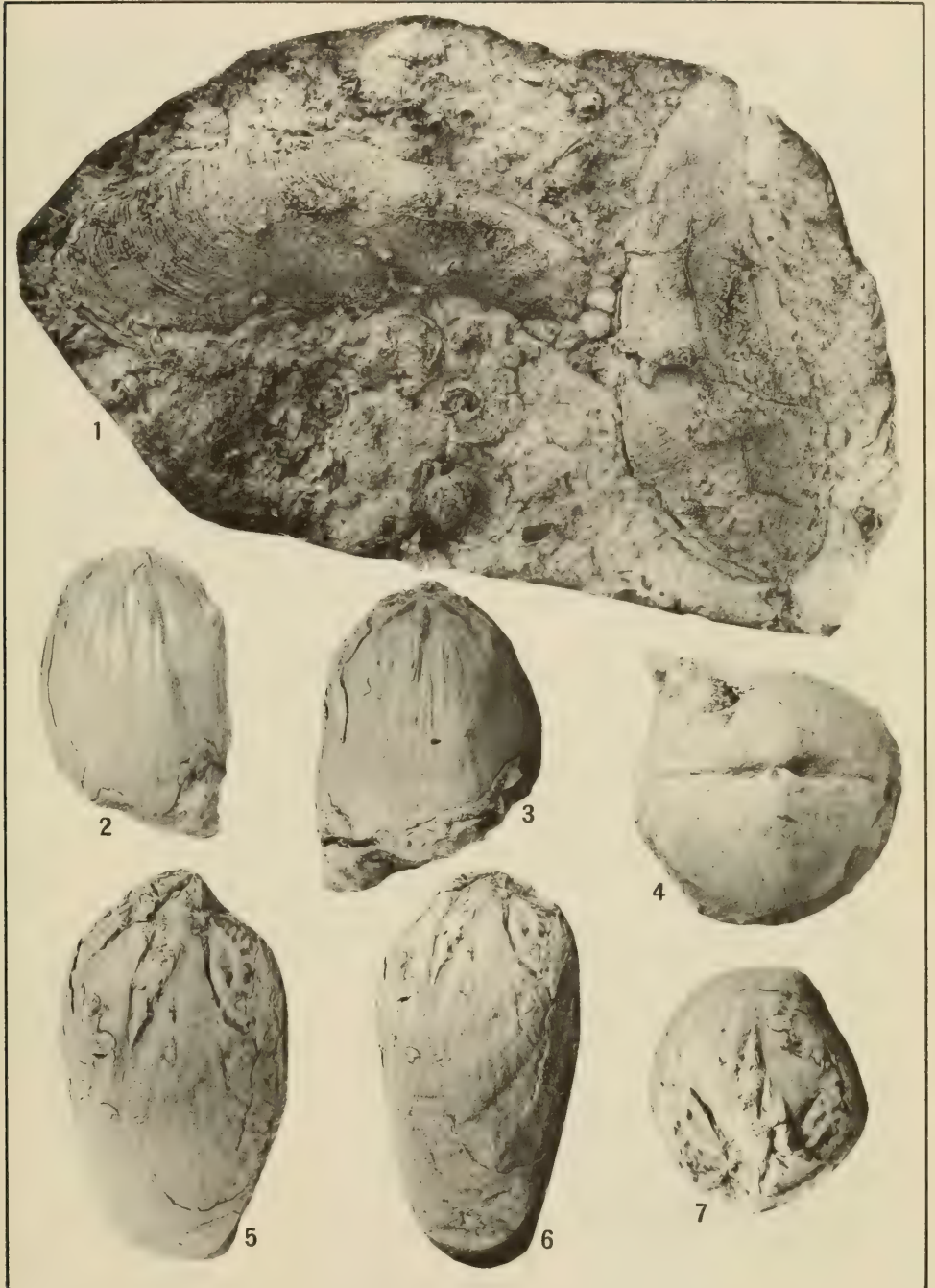
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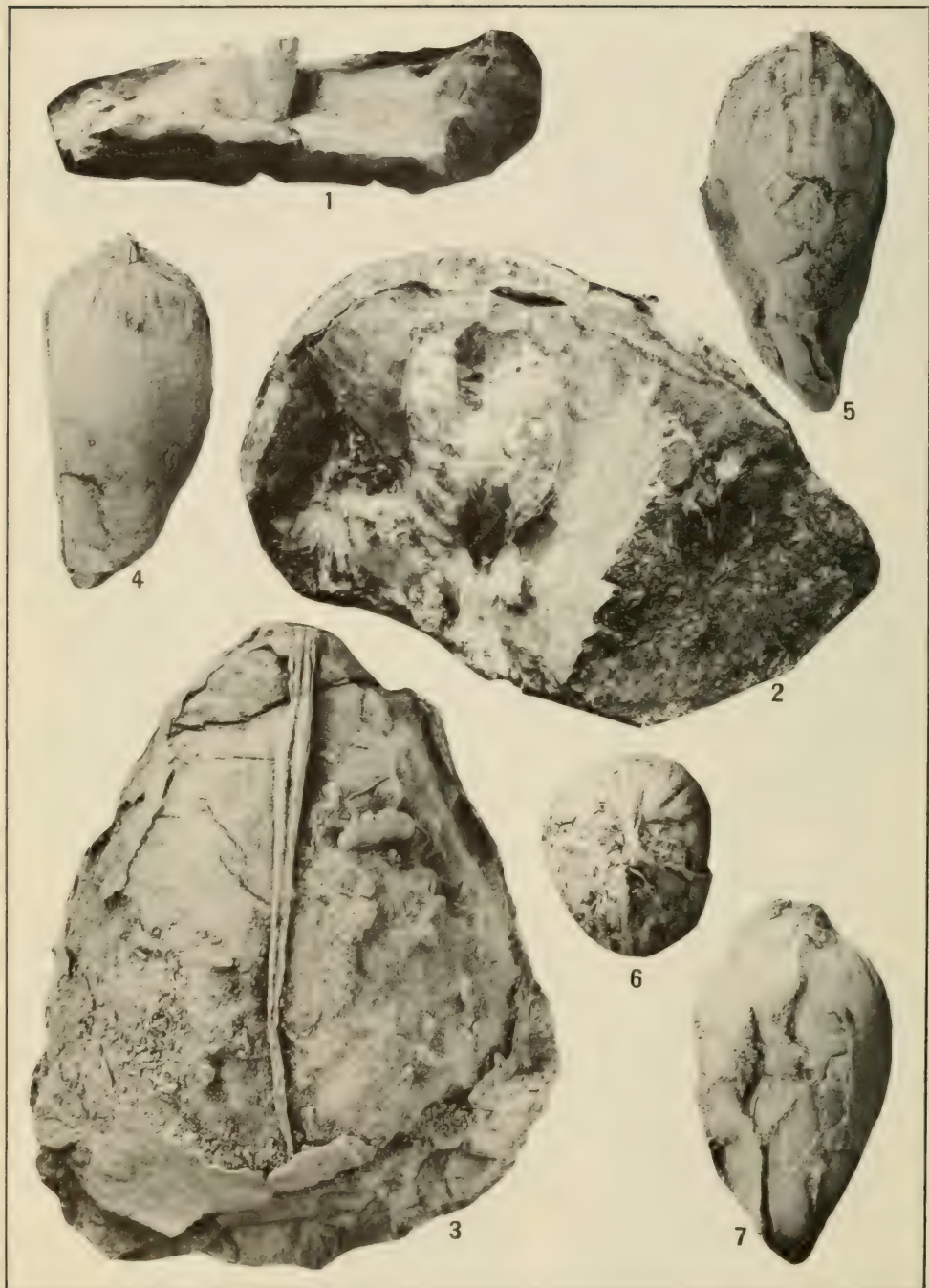
**SUBRENSSELANDIA**

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**LIROMYTIUS AND SUBRENSELANDIA**

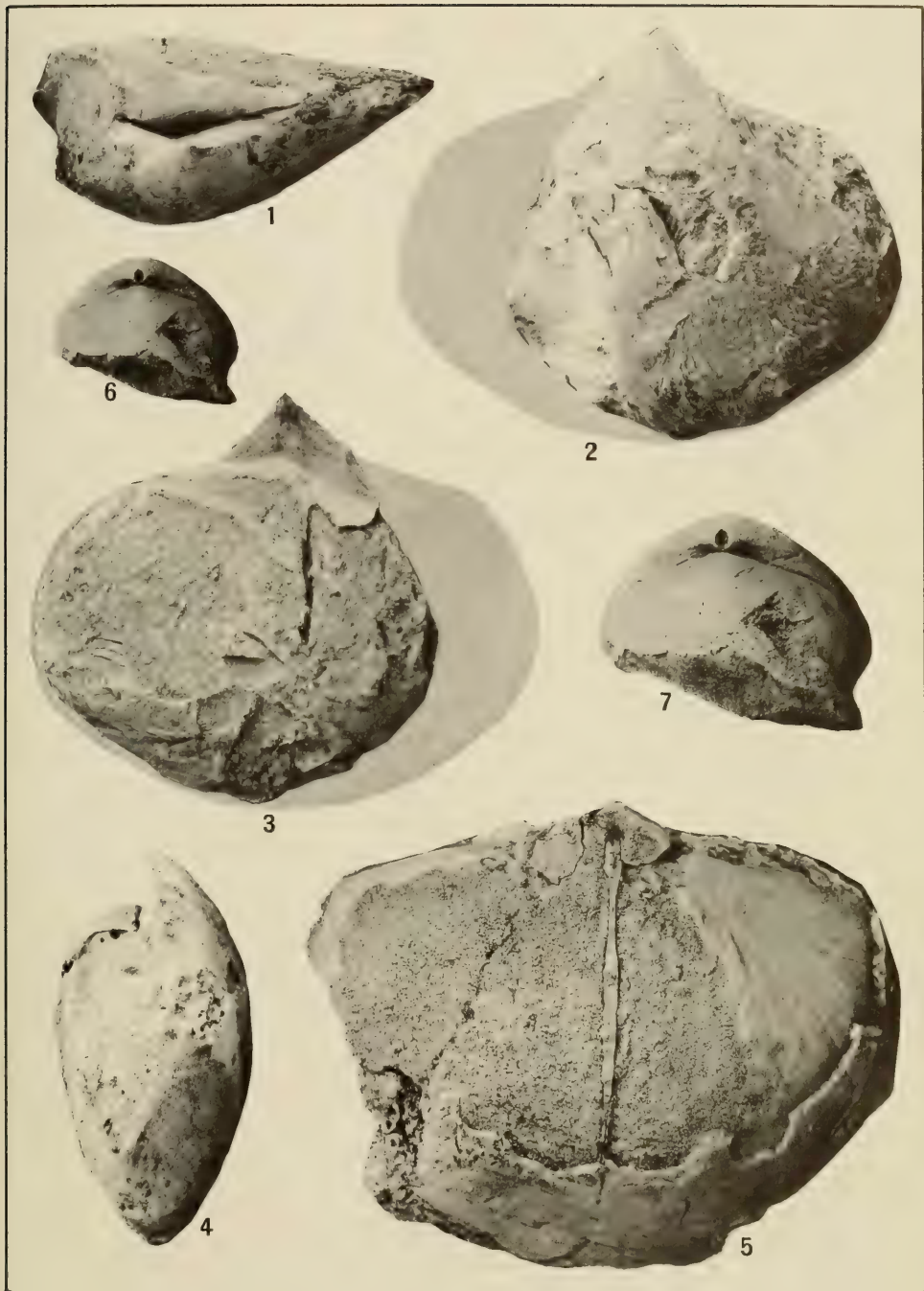
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**STRINGOCEPHALUS AND SUBRENSSELANDIA**

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**STRINGOCEPHALUS AND SUBRENSSELANDIA**

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